The effect of various types of sodium perborate bleaching agents on shear bond strength of a composite resin

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Aim: The purpose of this study was to evaluate various types of sodium perborates mixtures effect on shear bond strength of a composite resin.

Material and Methods: Eighty extracted central teeth were used in this study. The crowns were splitted mesiodistally from the incisal edges to cervicals. Buccal parts of the teeth were mounted in a 4 cm pipe with the use of cold acylic resin with their buccal surfaces downward. Dentin surfaces were polished and divided into 2 main groups according to the mixing solutions (n=40) (water or 30% hydrogen peroxide) and into four subgroups according to the sodium perborate type used (monohydrate, trihydrate, tetrahydrate and only the solution as a control) (n=10). The dentin surfaces of the groups were treated with fresh bleaching pastes and stored in an incubator. Composites were placed onto the dentin surfaces by packing the material into a cylindrical shaped matrix. Shear bond strength of each sample was measured and calculated in MPa.

Results: Mixing with hydrogen peroxide decreased bond strength values significantly ($p<0.05$). Higher bond strength values were obtained in tetrahydrate mixed with water group. Conclusions: For the success of composite restorative treatment that will be applied to non-vital colored teeth, mixing bleaching agents with water may be preferential.

KEY WORDS

Bleaching, perborates, dental bonding

The presence of discolored teeth is a serious esthetic problem and bleaching is the most conservative technique to improve their appearance (1). In pulpless discolored teeth, an intracoronal bleaching technique using 30% hydrogen peroxide with or without sodium perborate, has shown clinical success (2,3). Recently, more attention has been given to the possible adverse effects of bleaching treatment with hydrogen peroxide (4). Some of these adverse effects are: reversal of color following completion of bleaching treatment and external root resorption following bleaching treatment (5-9). The reduction in the adhesion in bleached enamel and dentin has also been reported with different restorative materials (10-14). Changes in the dental surface with hydrogen peroxide have been observed and these changes could be responsible for the reported decrease in adhesion (15,16).

In walking bleaching technique, sodium perborate in conjuction with hydrogen peroxide in varying concentreations is one of the most preferred bleaching preparations. It was reported that sodium perborate should be combined with water rather than hydrogen peroxide because of the lack of significant difference in success (17). However, bleaching efficacy does not only depend on the solvent used (water or hydrogen peroxide in different concentrations) but also on the type of sodium perborate (18). Sodium perborate was available as monohydrate (MH), trihydrate (TRH), and tetrahydrate (TH) and differs in their content of oxygen which can be considered as a measure of their potential bleaching efficacy (19).

These differences in their oxygen content may be changed with which solution used during their mixing and these changes in oxygen content may influence the surface of dentin and may change the adhesion of restorative materials.

Lack of sealing and adhesion between the final restoration and tooth

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structure may adversely affect the success of root canal treatment. As a result of development of dentin bonding systems, the opportunity of restoring non-vital teeth with resin composite has increased. The restoration of endodontically treated teeth with adhesive systems offers many advantages over the use of traditional materials. When composite resin is used to restore the cavity of a tooth, it is very important to achieve a good bond to pulpal dentin, to enchance retention and to maximize coronal sealing (20).

The effect of bleaching agents on dentin bond strength was previously studied but no study was found in the literature regarding the effect of different sodium perborate preparations on bond strength of final composite restorations (11,13). The purpose of this *in vitro* study was to evaluate the effect of different sodium perborate types mixed with hydrogen peroxide or bidistilled water solutions on shear bond strength of a commercial adhesive resin system (Kuraray Co., Ltd., Osaka, Japan) to human dentin.

MARTERIALS AND METHODS

80 non-carious and unrestored human maxillary central incisor teeth (extracted for periodontal reasons) were used. The specimens were stored at 4°C until the start of investigation. Teeth were decoranated and the crowns were splitted mesiodistally from the incisal edges to cervicals. Buccal parts of the teeth were mounted in a polyvinyl chloride pipe with the use of cold acylic resin with their buccal surfaces downward. The teeth were placed into a large, cool water bath to minimize any effect of heat from the cold acrylic's exothermic setting reaction. Dentin surfaces were then polished using 240-, 600-, and 800-grit silicon carbide papers until a flat dentin surface was achieved. Teeth were then randomly divided into 2 main groups according to the mixing solutions (n=40) (30% hydrogen peroxide or bidistilled water) and into four subgroups according to the sodium perborate type used (n=10). After removing the smear layer from the dentin surface with 15% ethylene diamine tetraacetic acid (EDTA), all the sodium perborate types mixed with 30% fresh hydrogen peroxide (Peroxid-Chemie GmbH, Höllriegelskreuth, Germany) or twice distilled water in a ratio of 1 g powder to 0.5 ml liquid. The corresponding chemical formulas and some of the physicochemical data of MH, TRH, TH are listed in Table 1.

The following mixtures were used to treat the experimental groups:

Group 1: Monohydrate (Degussa, Hanau, Germany) mixed with bidistilled water.

Group 2: The teeth were treated with trihydrate (Merck, Darmstadt, Germany) mixed with bidistilled water.

Group 3: Tetrahydrate mixed with bidistilled water mixture was applied to the dentin surface.

Group 4: This group was treated with only bidistilled water.

Group 5: Monohydrate mixed with hydrogen peroxide was applied.

Group 6: Trihydrate mixture with hydrogen peroxide was used.

Group 7: The teeth were treated with tetrahydrate mixed with hydrogen peroxide.

Group 8: This group was treated with only hydrogen peroxide.

During the experiment, the dentin surfaces of all the groups were treated with fresh bleaching pastes at 3 and 7 days and stored in an incubator at 37°C and 100% humidity. After pastes were removed carefully with a spoon excavator, dentin surfaces were rinsed with water. A self-etch adhesive system Clearfil SE Bond (Kurary Co., Ltd., Osaka, Japan) was used to restore the teeth according to the manufacturer's instructions.

The dentin surfaces to be bonded were isolated with the use of a custom-manufactured bonding jig (Ultradent Products Inc, South Jordan, Utah). After placement of the bonding jig over the specimens, a resin composite (Clearfil AP-X, Kuraray, Japan) was condensed into this special bonding jig's delrin cylinders with a diameter of 2.38-mm and light-cured for 40 seconds with a visible light unit operated at 730 mW/cm^2 (Kerr Dental). Specimens were stored at 37°C water for 24 h and then

Table 1.

Comparison of sodium perborate monohydrate, trihydrate and tetrahydrate

Sodium perborate	Monohydrate	Trihydrate	Tetrahydrate
Old formula	$NaBO_3H_2$	$NaBO_3$-$3H_2O$	$NaBO_3$-$4H_2O$
Correct formula	2 x $NaBO_2$-$(OH)_2$	2 x[$NaBO_2$-$(OH)_2$]-$4H_2O$	2 x [$NaBO_2$-$(OH)_2$]-$6H_2O$
Content of active oxygen (%)	16.0	11.8	10.4
Solubility in water (20°)	15 g l^{-1}	11.8 g l^{-1}	23 g l^{-1}

were perpendicularly engaged at their bases with a custom probe (Ultradent Products) in a universal testing machine (Model 5566; Instron Corp, Canton, Mass.) at a crosshead speed of 1.0 mm/min until failure. Shear bond strength values were calculated as MPa. The data were analyzed by two-way analysis of variance, and Mann-Whitney U test. After testing, the fracture modes of each specimen were examined in a dissecting microscope at 22x magnification (SZ-TP Olympus, Japan). The fractured surfaces were classified according to one of three types: Type I: adhesive failure between bonding resin and dentin; Type II: cohesive failure in the dentin and resin or composite resin and Type III: mixed (partial adhesive failures mixed with the partial cohesive failures in resin).

RESULTS

The results of the effect of different sodium perborate types on shear bond strength of a adhesive resin and failure modes are summarized in Table 2. Statistical analyses of the data showed significant differences among the groups ($p=0.000$).

Group 3 showed higher bond strength values then Group 1 and Group 2 ($P<0.05$). There was not a statistically significant difference among the shear bond strengths of trihydrate and monohydrate groups, no matter which solution were used in mixing ($P>0.05$). In general, mixing sodium perborate types with 30% hydrogen peroxide (Group 5, 6 and 7) resulted in a 32.19% decrease in shear bond strength of bonding agent used. Mixing with hydrogen peroxide significantly reduced shear bond strengths in tetrahydrate group (Group 7) ($P<0.05$), but did not have a significant effect in monohydrate and trihydrate groups (Group 5, 6). Generally adhesive failures were observed mostly in all groups.

DISCUSSION

The result of this study has shown that there was a statistically significant difference between the mean shear bond strength of the groups mixed with hydrogen peroxide or groups mixed with bidistilled water.

Titley et al have shown a massive reduction in shear bond strengths when cylinders of composite resin are bonded to bovine enamel treated with 35% hydrojen peroxide (10). Stokes et al (12) detected a significant decrease in the shear bond strength of resin composite to human enamel after use of 30% hydrogen peroxide for 2 hours. DeMarco et al (22) reported that use of 30% hydrogen peroxide for 1 hour interferes with the bonding mechanism of fourth generation dentin bonding agents to bleached dentin. Reduction of bond strength to bleached enamel and dentin has also been reported with different restorative materials (10-14).

This study has shown that the shear bond strength of a self-etch adhesive system decreased significantly after the use of a 30% hydrogen peroxide in bleaching treatment. These results are in accordance with those found in current literature (10-12,14). Changes in the dental surface with 30% hydrogen peroxide have also been observed and these changes could be responsible for the reported decrease in adhesion (15,16). The presence of oxygen or a breakdown product of hydrogen peroxide, has been reported to be related to the reduction in bonding (23). Oxygen may inhibit curing of composites, therefore may reduce the adhesion. The dental surface changes following bleaching could be time dependent as reported for bleached enamel and dentin (22,24). A delay in bonding may solve the problem (22,24).

Table 2.

The effect of different sodium perborate types on the shear bond strength of dentin

Groups	n	Mean±SD	Failure type Adhesive/cohesive/mixed
Monohydrate+water (MH+ H_2O)	10	18.87 ± 4.79^{a}	9/1/0
Trihydrate +water (TRH+ H_2O)	10	18.96 ± 5.77^{a}	9/0/1
Tetrahydrate +water(TH+H_2O)	10	26.67 ± 1.92^{b}	6/3/1
Bidistilled water (H_2O)	10	27.23 ± 2.77^{b}	5/4/1
Monohydrate+Hydrogen peroxide (MH+ H_2O_2)	10	14.16 ± 4.08^{ad}	8/1/1
Trihydrate + Hydrogen peroxide (TRH+ H_2O_2)	10	17.04 ± 4.11^{a}	9/1/0
Tetrahydrate + Hydrogen peroxide (TH+H_2O_2)	10	12.54 ± 440^{cd}	10/0/0
Hydrogen peroxide (H_2O_2)	10	4.44 ± 1.58^{e}	10/0/0

* The same letters in the column are not statistically significant ($P>0.05$).

#Adhesive failure between bonding resin and dentin, cohesive failure in the dentin and resin or composite resin, mixed: partial adhesive failures mixed with partial cohesive failures in resin

In the walking bleaching technique, a thick paste of sodium perborate mixed with hydrogen peroxide or water is placed in the pulp chamber for periods of 3 to 7 days (25). However, external cervical root resorption has been reported to occur following intracoronal bleaching of discolored pulpless teeth with walking bleaching technique when hydrogen peroxide was used (7). Therefore, it is recommended that sodium perborate should be mixed with water rather than hydrogen peroxide in order to prevent or minimize the occurrence of bleaching related external root resorption (18). Sodium perborate is a white crystalline odourless powder. When sodium perborate contacts with moisture, it decomposes to hydrogen peroxide, changing the pH of the bleaching solution. In a second step, hydrogen peroxide may release oxygen and starts the bleaching process (19). The content of active oxygen depends on the content of water of crystallization in the three different forms of sodium perborate (19). In the present study, each composition was mixed either with 30% hydrogen peroxide or bidistilled water and applied to the dentin surfaces prior to the adhesive bonding.

Weiger et al (19) showed that MH has the highest content of active oxygen with 16%. In conjuction with water or hydrogen peroxide, it solidifies after 1 hour (at the latest) and becomes inefficient. For TRH (content of active oxygen =11.8%) the solidification occurs after 1 day (19). Only TH (content of active oxygen=10.4%) combined with both solvents keep its consistency after 7 days (19). In this study, during the experimental interval, three sodium perborate types were applied at day 3 and 7 as usually recommended for the bleaching technique (26). At the end the results were in agreement with Weiger et al.(18) in that, MH and TRH have limited duration of effect, because when they combined with both water or hydrogen peroxide, they solidifies and becomes inefficient. That may explain our results about the absence of significant difference between shear bond strength values of MH and TRH combined with both solvents.

We obtained highest shear bond strength values in tetrahydrate mixed with water group (Group 3). A possible explanation to this result is lower active oxygen content of tetrahydrate. Because active, gaseous oxygen escapes immediately and thereby get lost for the bleaching process. MH and TRH have higher active oxygen content than TH. When they get lost after being applied to the dentin surfaces, they may trapped by the dentin tubules opened by EDTA. Also porous dentin (27) could be conceptualized as a reservoir, retaining oxygen radicals. The reservoir of gaseous or dissolved oxygen products would persist in our study because in nonvital teeth we don't have pulpal circulation and also diffusion from the external surface can not be possible because of the solidified paste. These trapped oxygen radicals can be start getting lost after removal of the paste prior to the bonding and some of them may inhibit the polymerization of resin. Resin composite restoratives and bonding agents contain accelerators which release free radicals that facilitate long-chain polymer formation (28). Oxygen inhibits polymerization by preferentially reacting with the monomeric accelator radicals. Quantities of oxygen in fractions as small as parts per million, have been reported to retard polymerization (29). When we look at the shear bond strength values of all the hydrogen peroxide mixed groups, although there was not a statistically significant difference, lower bond strength values were obtained than bidistilled water mixed groups. Free oxygen should be in higher quantity in perborates mixed with hydrogen peroxide applied groups because of the extra oxygen which comes out as a byproduct of hydrogen peroxide and these can act adversely over the degree of curing the composite (22).

Toko & Hisamitsu (13), Shinohara et al (31) and Timpawat et al (32) observed a reduction in the shear bond strength between the composite and human dentin following the surface treatment with walking bleaching technique (30% hydrogen peroxide plus sodium perborate or sodium perporate). Our results are in agreement with their results. The reduction in adhesion of final restoration can not only facilitate the microleakage (29), but also expose the filled root canal system to the oral environment and allows penetration of microorganisms from a coronal direction. This contributes to the failure of the root canal treatment and is the principal cause of color reversal after the bleaching treatment (4).

CONCLUSION

Internal dentin bleaching using hydrogen peroxide as sole bleaching agent or mixed with sodium perborates on teeth may compromise the ultimate retention of the final restoration if a composite material used. Whether the degree of reduction is sufficient to affect the clinical performance of the restoration has yet to be determined. Until further investigation of this matter is undertaken, the use of walking bleaching technique with other sodium perborate types than tetrahydrates and their hydrogen peroxide mixtures can only be advised with caution.

Farklı perborat ağartma ajanlarının bir kompozit rezinin makaslama bağlantı dayanımı üzerine etkisi

Amaç: Bu çalışmanın amacı farklı tiplerdeki sodyum perborat karışımlarının bir kompozitin makaslama bağlantı dayanımına etkisini araştırmaktır.

Gereç ve yöntemler: Çekilmiş 80 keser diş bu çalışmada kullanılmıştır. Dişlerin kronları mezyodistal olarak insizalden servikale doğru ayrılmıştır. Diş örnekleri bukkal yüzeyleri 4 cm derinliğindeki silindir borulara soğuk akrilik yardımıyla bukkal yüzeyleri aşağıda kalacak şekilde gömüldü. Dentin yüzeyleri cilalandı ve karıştırmada kullanılacak solüsyonlara göre (su veya 30% hidrojen peroksit) (n=40) önce iki ana gruba ayrıldı ve sonrasında kullanılacak sodyum perboratın tipine göre 4 alt gruba ayrıldı (n=10) (monohidrat, trihidrat, tetrahidrat ve sadece solüsyon-kontrol olarak). Gruplardaki dentin yüzeyleri daha sonra taze hazırlanmış ağartma materyaller ile muamele edilerek, inkübatörde saklandı. Silindir şekilli özel matrisler kullanılarak 3 mm uzunluğunda kompozit yapılar dentin yüzeylerinde oluşturuldu. Her örneğin makaslama bağlantı dayanımları ölçülerek, MPa çevrildi.

Bulgular: Hidrojen peroksit ile karıştırmanın bağlantı dayanımını önemli ölçüde düşürdüğü belirlendi ($P<0.05$). Daha yüksek bağlantı değerleri tetrahidratın su ile karıştırıldığı gruplarda elde edildi.

Sonuç: Non-vital ağartma uygulanacak dişlerde ağartma ajanlarının su ile karıştırılması dişlere yapılacak ileriki kompozit restorasyonların başarısı açısından tercih edilmelidir.

Anahtar Kelimeler: Ağartma, perboratlar, bağlantı

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